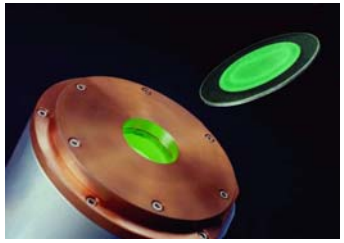
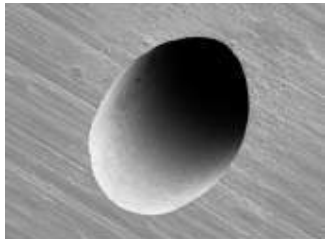
TRUMPF

High power picosecond lasers are ready for production



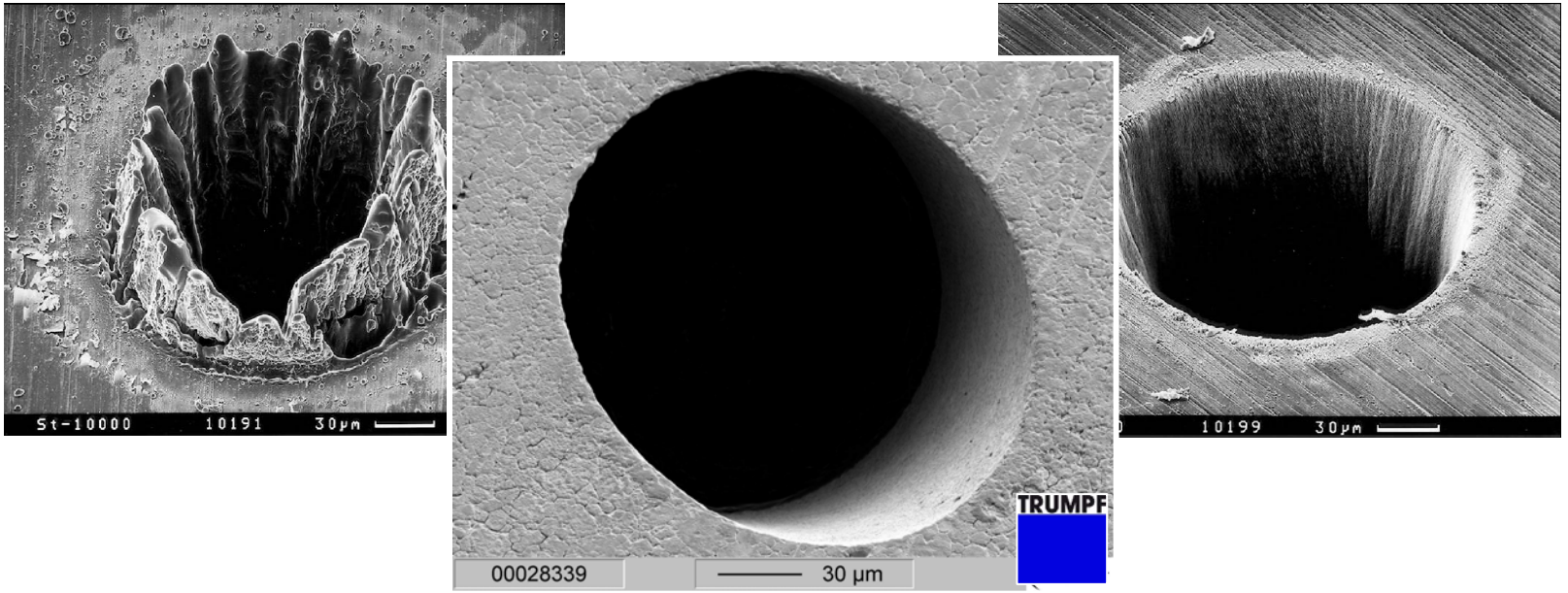


Dr. Sascha Weiler

TRUMPF Laser GmbH + Co. KG
78713 Schramberg

Picosecond Lasers: fs Quality with ns Speed

ns pulses ps pulses fs pulses



C. Momma, B.N. Chichkov, S. Nolte, F. von Alvensleben, A. Tünnermann, H. Welling, B. Wellegehausen, “Short-pulse laser ablation of solid targets”, Opt. Commun. **129**, 134 (1996)

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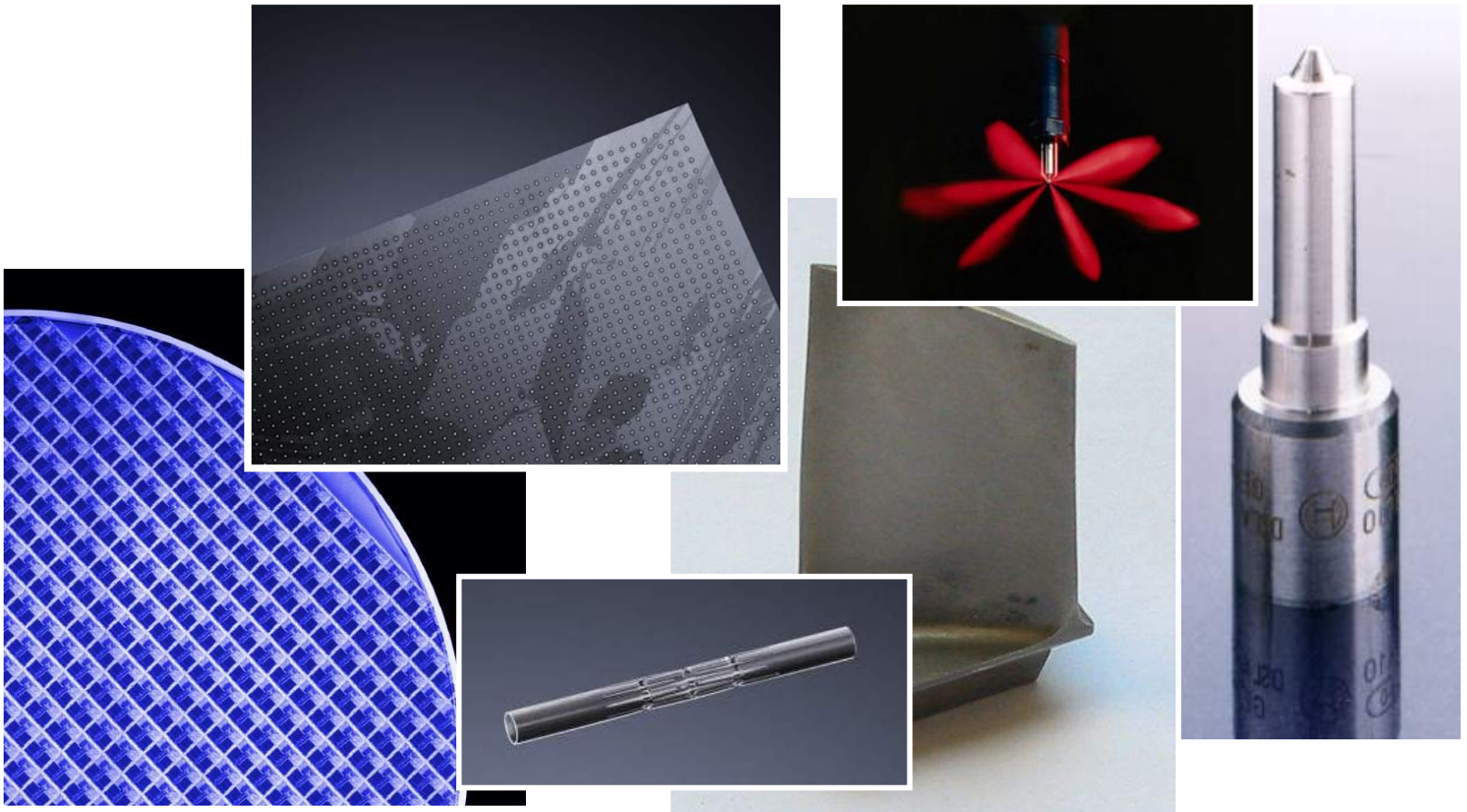
Micromachining with Picosecond Lasers



Drilling with picosecond pulses

- Phase 1: „Digging in“
  (t ≤ 1 ms)

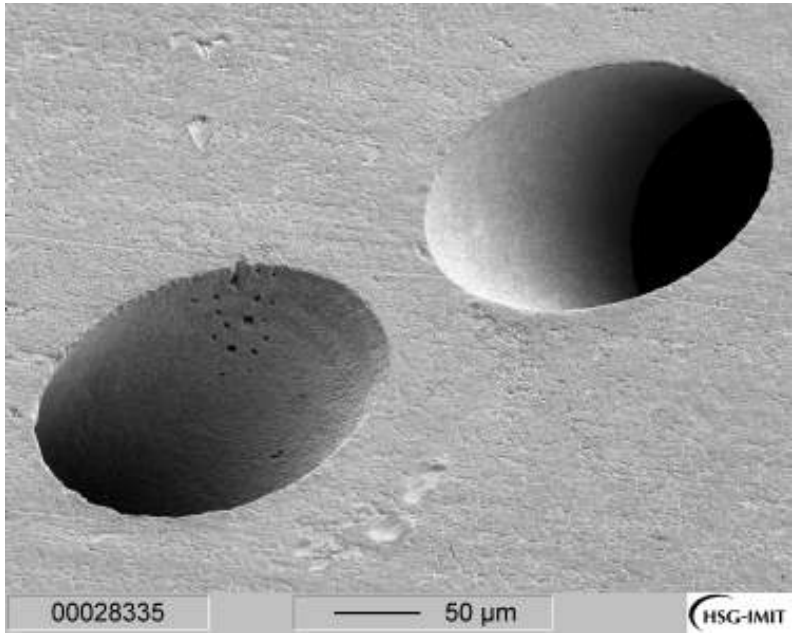
- Phase 2: Drilling through
  (t = 1 ms - 1s)

- Phase 3: Forming the Exit Side
  (t = 0.01 - 10 s)

Drilling with high Aspect Ratio

Helical Drilling of Stainless Steel

- No melt or debris
- No Heat Affected Zone
- Free selection of taper (positive, negative or zero)
- Diameters: 50 to 100 µm
- Material thickness: up to 1.5 mm
- Applications: Injectors, cooling holes, filters



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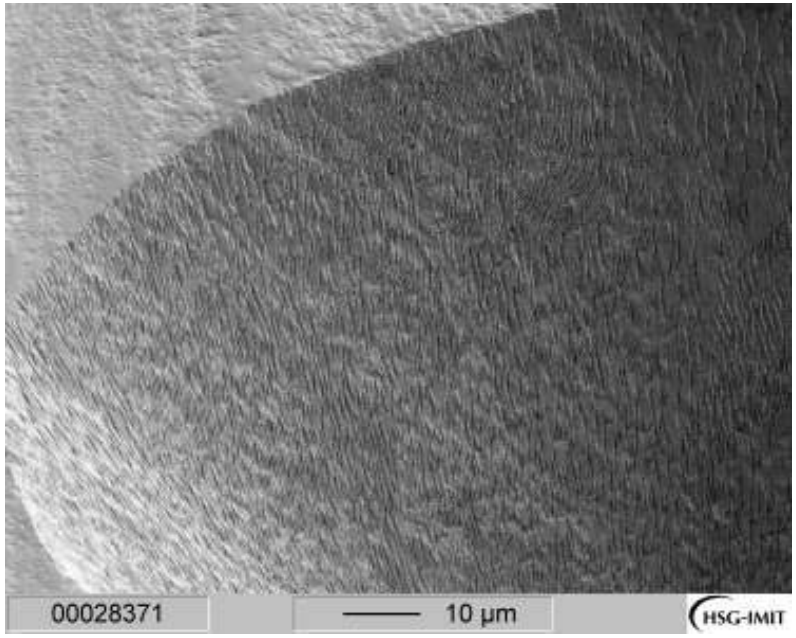
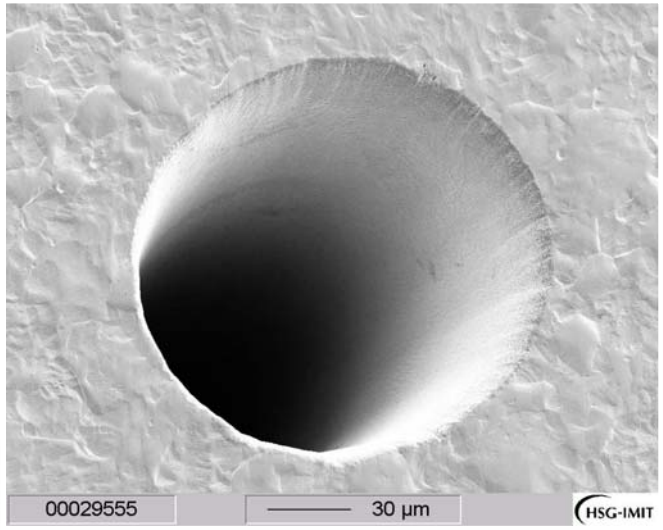


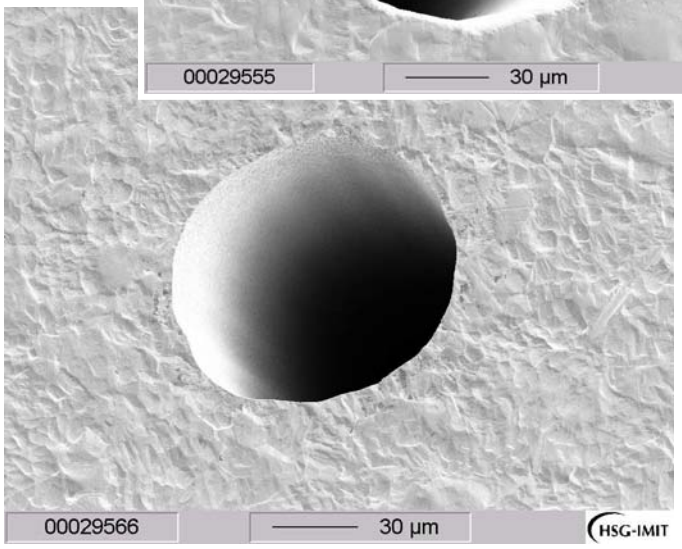
Drilling with high Aspect Ratio

Helical Drilling of Titanium

- No melt or debris
- No Heat Affected Zone
- Free selection of taper (positive, negative or zero)
- Diameters: 50 to 100 µm
- Material thickness: up to 2 mm
- Applications: cooling holes for turbine blades



Entrance

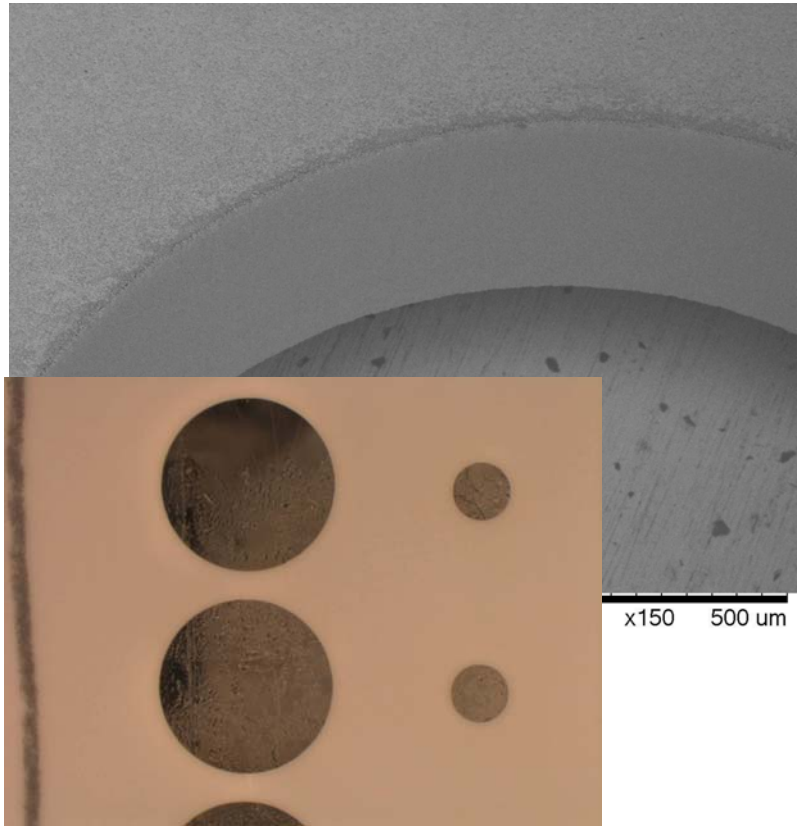


Exit

Drilling with low Aspect Ratio

Drilling of Ceramics (AlO, AlN, etc.)

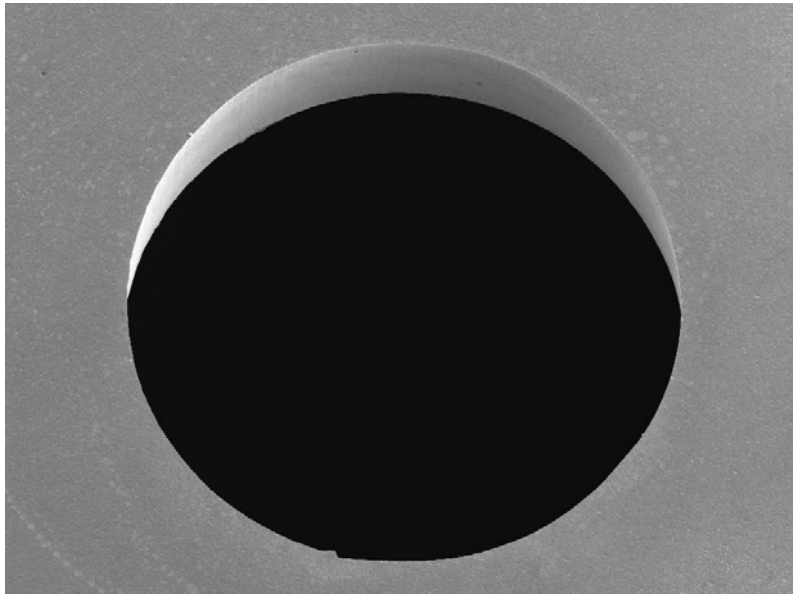
- Percussion Drilling / Trepanning with Scanner Optics
- Diameters < 100 µm – X mm
- Low HAZ
- No Chipping/Cracking
- Applications: Ceramic PCB



Drilling with low Aspect Ratio

Drilling of Silicon

- Percussion Drilling / Trepanning with Scanner Optics
- Diameter < 100 µm – X mm
- Low HAZ
- High edge quality
- Application: Through Silicon Vias for 3D packaging

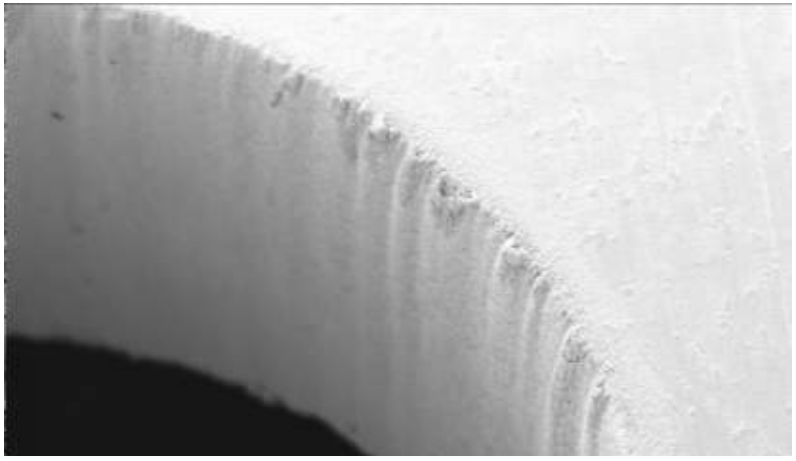


Cutting

Cutting with picosecond pulses

Cutting of Nitinol

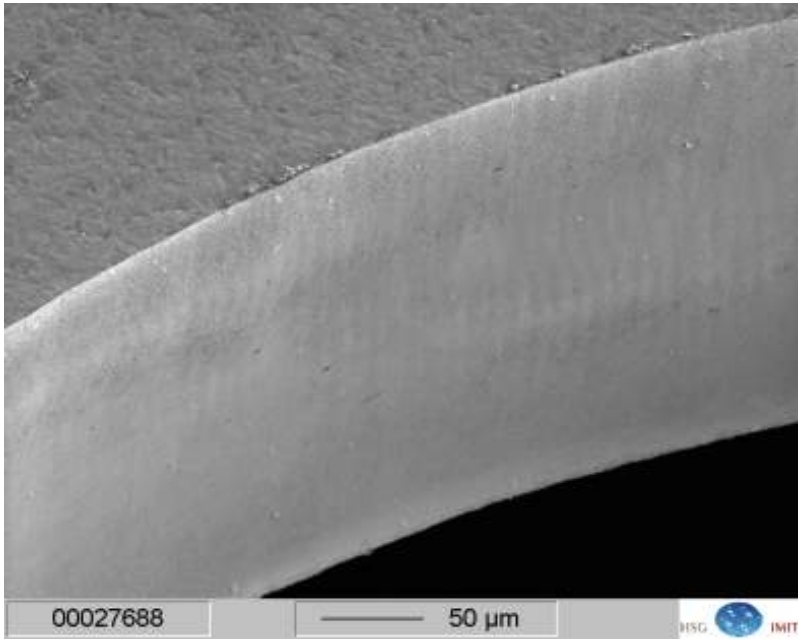
- Small cutting kerf (< 10-20 µm)
- Negligible HAZ
- High quality of cutting edge
- No electro polishing!
- High yield
- High productivity due to high average power
- Application: Cutting of Stents, endoscopes



Cutting with picosecond pulses

Cutting of Silicon Wafers

- Small cutting kerf (< 20 µm)
- Negligible HAZ
- High quality of cutting edge
- High productivity due to high average power
- Applications: Waferdicing



Cutting with picosecond pulses

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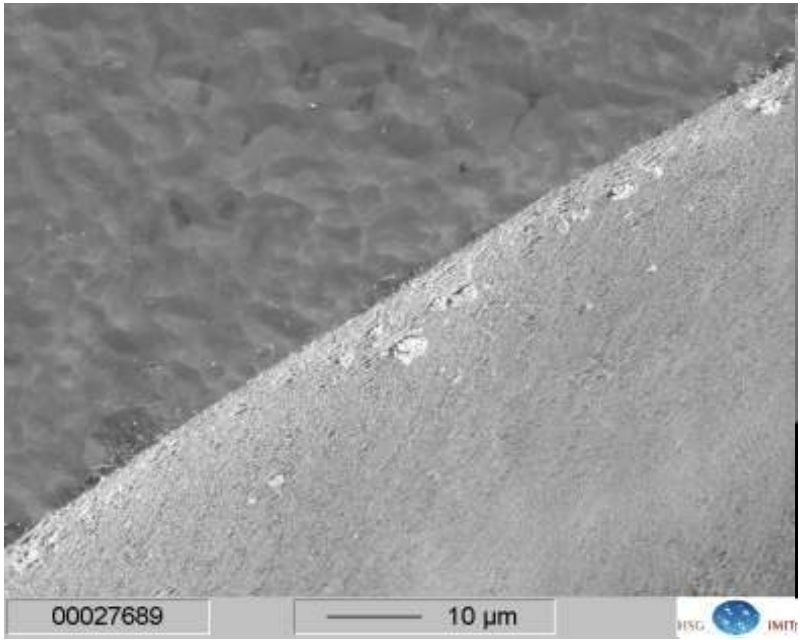
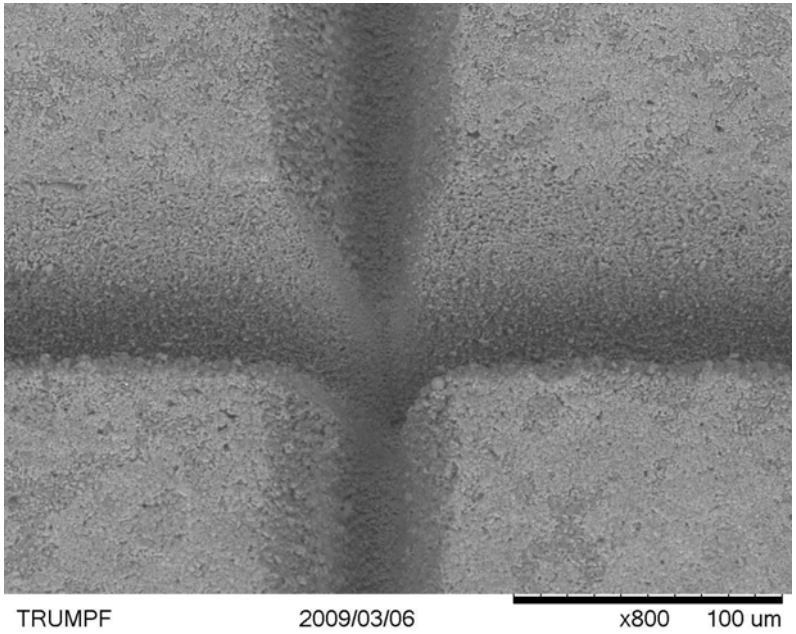


Cutting with picosecond pulses

Scribing and cutting of Ceramics

- Small kerf width (< 20 µm)
- Negligible HAZ
- High quality of cutting edge
- High productivity due to high average power
- Applications: Scribing / cutting of ceramic PCBs



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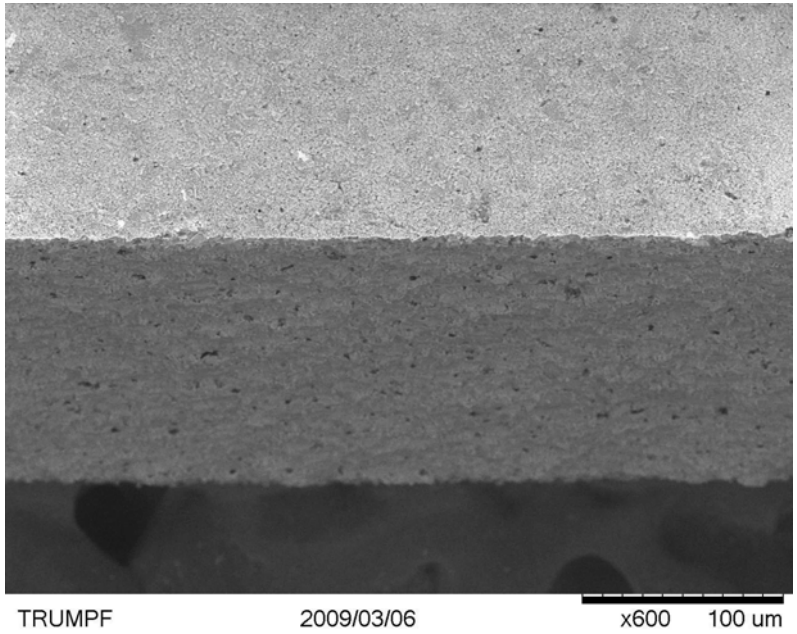
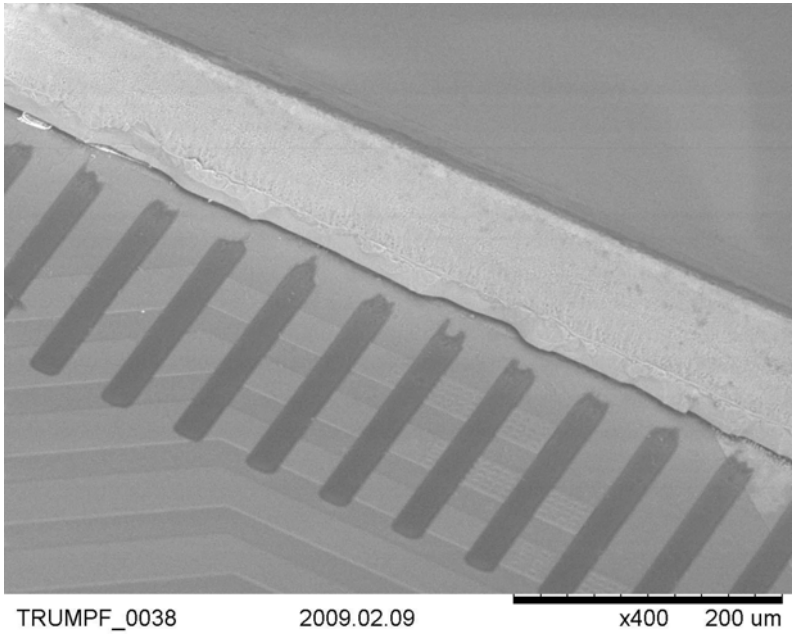


Cutting with picosecond pulses

Scribing and cutting of thin glass

- Small kerf width (< 20 µm)
- Negligible HAZ
- High quality of cutting edge
- High productivity due to high average power
- Application: Scribing/cutting of thin glass for Flat-Panel-Displays

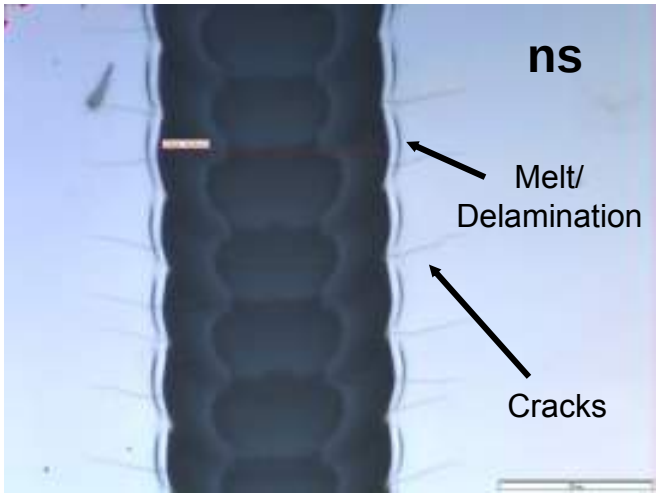


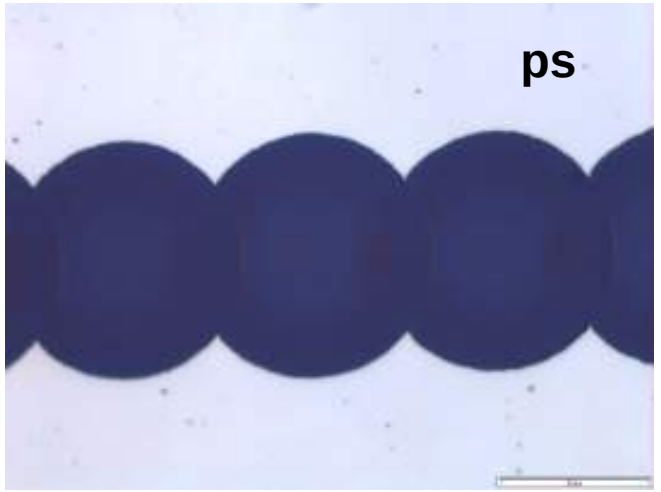
Thin Film Ablation with picosecond pulses

Thin Film Ablation

Laser patterning of thin Mo on glass

- Burr free
- Melt free
- No delamination
- Isolated channel
- Application: P1 step for CIGS cell connection



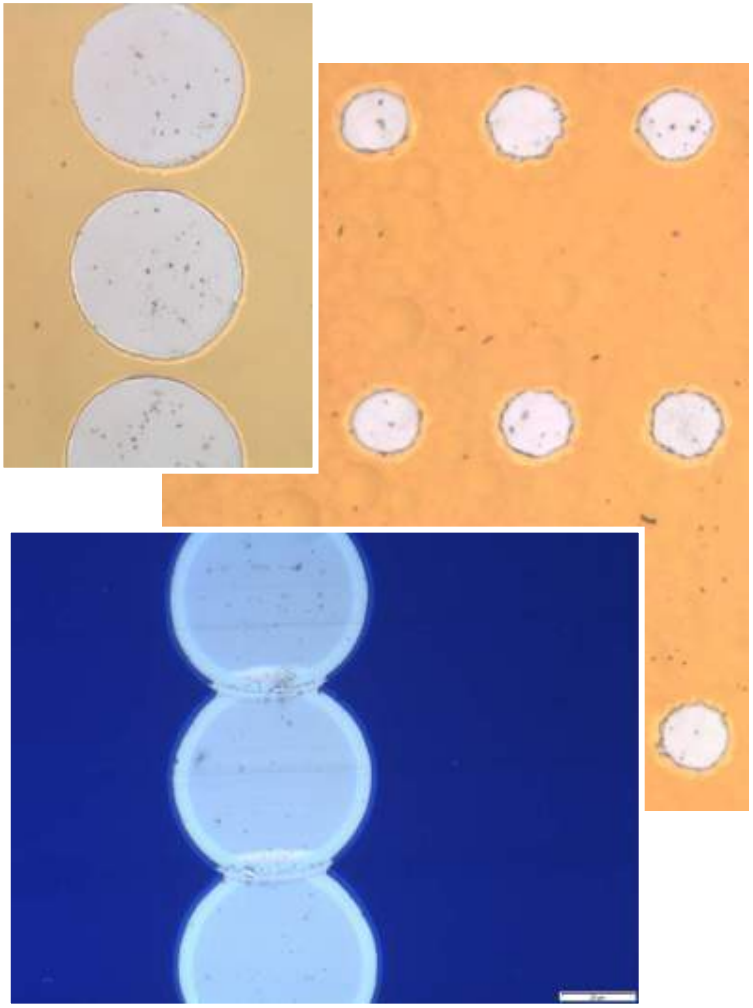


Thin Film Ablation

Laser patterning of thin films on Silicon

Direct patterning of SiO/SiN layers

- Thickness of layers: 100 nm
- Single shot ablation
- Selective removal without affecting base material (Silicon)
- Application: Cell connection for Silicon Solar Cells, low-k dielectric grooving



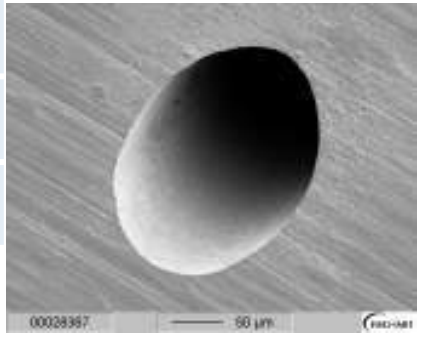
General Demands for Industrial Lasers

General Demands for Industrial Lasers

- High productivity

TruMicro Series 5000

	TruMicro 5050	TruMicro 5250	TruMicro 5350
Average Power	50 W	25 W	> 15 W
Wavelength	1030 nm	515 nm	343 nm
Pulse Duration	< 10 ps	< 10 ps	< 10 ps
Max. Pulse Energy	250 µJ	125 µJ	> 75 µJ
Repetition Rate*	200/400 kHz	200/400 kHz	200/400 kHz
Beam Quality	M ² < 1.3	M² < 1.3	M² < 1.3



* Higher Repetition Rates upon request

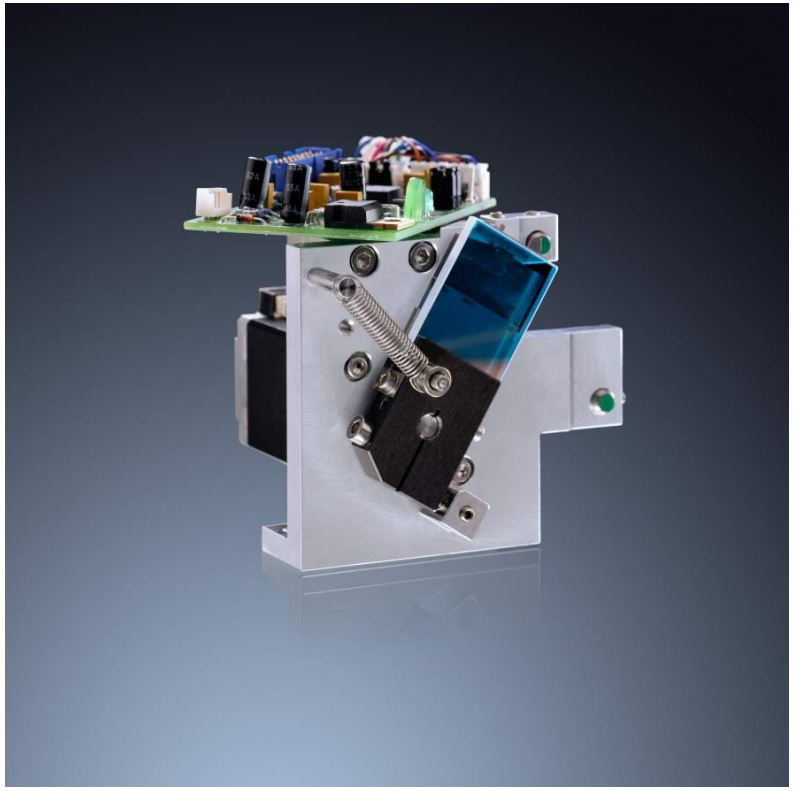
General Demands for Industrial Lasers

- High productivity AND high duty cycle

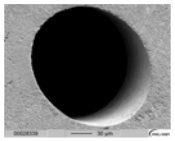
External Multiplexing

- External beam switches for multiplexing
- Up to 4 beam switches incl. safety circuit
- Easy integration in TruControl
- Maximise Laser-on Time

→ Maximise Productivity



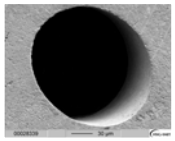
Machine concept for external multiplexing



Absorber/
Powermeter

PLC (Integrator)

Machine concept for external multiplexing



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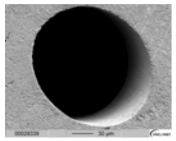


Absorber/
Powermeter

PLC (Integrator)

Machine concept for external multiplexing

Absorber/
Powermeter

PLC (Integrator)

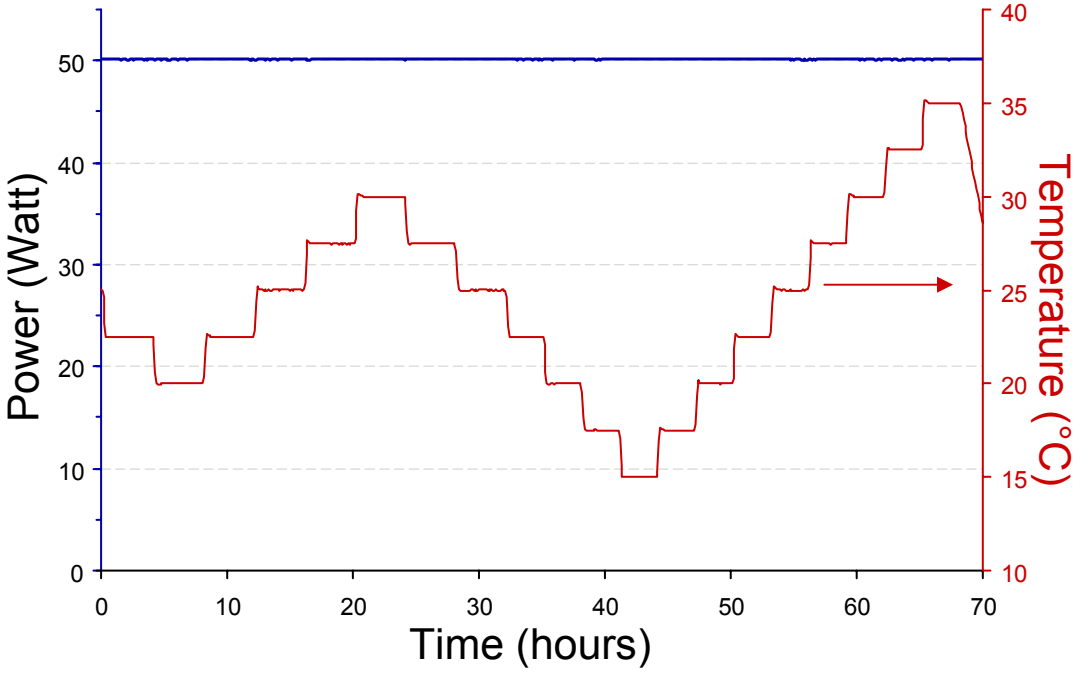
TRUMPF

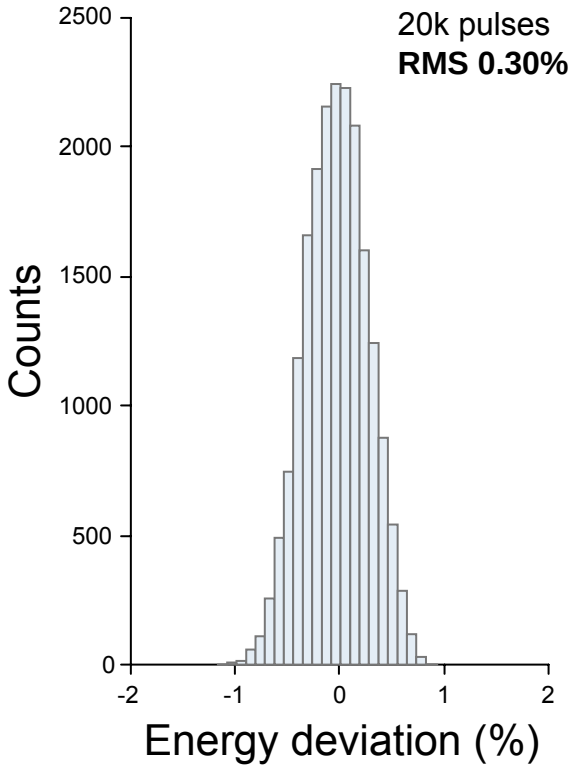
General Demands for Industrial Lasers

- High productivity, high duty cycle, high stability

TruMicro 5050 - Stability

- Guaranteed Power stability < 1,5% for ambient temperatures of 20 – 30 °C
- Guaranteed Energy Stability: < 2% (RMS)





TRUMPF

General Demands for Industrial Lasers

- High productivity, high duty cycle, high stability
- High availabilty (> 98 % @ 24/7)
- Worldwide service and support 24/7 (Telepresence)

TelePresence Portal – Facts & Figures

- Almost 100% of the devices are supplied with integrated modem and give the ability to TelePresence
- For 70 - 80% of the delivered devices our customers make use of TelePresence
- > 90% of all incoming inquiries can be solved without on-site action
- 80% of the cases are diagnosed within 15 minutes
- Only about 50% of the cases are defects – the other 50% are operation-, activation- and integration problems or system calibration
- TRUMPF has so far the only remote maintenance solution certified by the Federal Office for Safety in the Information Technology (BSI)!

TRUMPF

General Demands for Industrial Lasers

- High productivity, high stability
- High Availabilty (> 98 %)
- Worldwide service and support 24/7 (Telepresence)
- Long Service Intervals (> 5000 h)
- Long Lifetime of Pump Diode (> 20000 h)
- Low Total Cost of Ownership (< 10 Euro/hour)
- Process development and optimization in-house and on customer site

Summary

For industrial picosecond lasers a only combination of

- Short pulses (< 10 ps)
- High average power (> 50 W)
- High pulse energy (> 150 - 250 µJ)
- High (but not too high for scanner speeds) pulse frequency (200 - 400 kHz)

while GUARANTEEING

- Best beam quality (M^2 < 1,3)
- High beam roundness (> 90 %)
- High pulse to pulse stability (< 2 %)
- High availability (> 98 %) and low TCO

enables for efficient and cost-effective micro machining!

Thank you!

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